Title: **Growing Pinyon Pine and Subalpine Fir Seedlings in Fabric and Plastic Containers**

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FINAL STATUS OF THE PROJECT

Abstract:

Pinyon pine (*Pinus edulis*) and subalpine fir (*Abies lasiocarpa*) seedlings are native species that can be difficult to transplant, but shading young plants and growing them in containers may improve their survival. The objective of this study was to determine the effects of light treatment and type of container on survival and growth of these seedlings. Plug seedlings (2-0) of both species were the only plants available for this study. Seedlings were planted in a bark-based potting mix in one-gallon plastic or fabric containers. The container plants were then grown in full sun or 55% shade. The experiment began in mid-May and ended in mid-October. Over 98% of both species of seedlings survived in this experiment. Both species of seedlings grew best in full sun, although shaded fir plants averaged 1.5 cm taller than those grown in full sun. An interaction between light treatment and type of container showed that fir seedlings grown in full sun in fabric pots had 3.2% larger stem diameters and 20% higher root dry weights than those receiving any other treatment combination. In contrast, only light treatment affected pine seedling growth, with plants grown in full sun having significantly larger stem diameters and root dry weights. This study demonstrated that plug subalpine fir seedlings should be grown in full sun in fabric pots to obtain maximum growth, whereas plug pinyon pine seedlings can be grown in full sun in regular plastic pots to obtain maximum growth.

Materials and Methods:

In this experiment, pinyon pine (*Pinus edulis*) and subalpine fir (*Abies lasiocarpa*) seedlings were grown in fabric or plastic containers, and these containers were placed in full sun or 55% shade. Plug seedlings (2-0) of both species were the only plants available and were used in the study rather than bareroot plants. Regular 1-gallon (3-liter) plastic pots were used as one treatment. Fabric containers equivalent to 1-gallon size were obtained from Root Control, Inc., Oklahoma City, Oklahoma. All seedlings were planted in a bark-based potting mix that consisted of 80% aged pine bark, 10% silica sand, 5% Eko® compost, and 5% sphagnum peat moss (by volume). This mix was supplemented with MicroMax (micronutrient) fertilizer at the labeled rate of 1.5 lbs. per cubic yard and 15-9-12 Scott's Osmocote® (controlled-release) fertilizer at the labeled rate of 8 lbs. per cubic yard before planting. An extra treatment, using

55% shade (compared against full sun), was also included in this study even though this treatment was not included in the original grant proposal. The experiment consisted of two types of pots (fabric vs. plastic) and two light treatments (55% shade vs. full sun).

The treatments were used in a factorial experiment and were arranged in a randomized complete block design. All seedlings were randomly assigned to a container type and light treatment (shade or sun). Seedlings were planted by April 24 and allowed to establish for 3 and a half weeks under ambient conditions in full sun before arranging the plants in blocks under sun or shade treatments (on May 17). All plants were fertilized with Peters® 30-10-10 at 150 ppm N on June 23, July 7, and July 21. Each of the four blocks contained two types of containers used in two light treatments with each treatment containing six replications. Therefore, 96 seedlings of each species were used in this study (4 blocks x 2 container types x 2 light treatment x 6 replicates per treatment). A low-volume irrigation system outfitted with spray stakes was used to water all containers. Seedlings were watered twice a day during the hot weather (most of the summer) and received 1.6 liters of water each day.

The potting media were tested for pH, electrical conductivity (EC), and the physical characteristics of aeration (also called air-filled porosity), water-holding capacity, and total porosity. The initial pH and EC of the media were determined for four samples by using the saturated extraction method. After one month, the pour-through method (also called the Virginia Tech. method) was used to determine potting mix pH and EC for three randomly selected plants.

All seedlings used in this experiment were harvested by October 18. Plant roots were washed free of potting mix after the plants were gently removed from their growing location and pots. Many plants rooted into the mulch bed where they were growing, particularly those grown in the fabric pots. Since many plants had roots outside the fabric containers, root volume measurements were dropped from this study. The 2006 terminal leader growth of the seedlings and mean stem diameters were measured. The plants were cut at the root-stem crown after being measured, and roots and shoots were dried separately to determine their dry weights.

Statistical analyses of the data included using analysis of variance on the plant growth data. The overall probability needed to show significant treatment effects had to be at or below the 5% level ($P \leq 0.05$) when completing the various statistical analyses. Mean separation tests were completed only if the statistical model was significant. In other words, the shade treatments or type of pot used, or both affected the type of plant growth being analyzed. Least Square means were used to determine treatment differences at the 5% level.

Results and Discussion:

The potting mix used in this study had a reasonable initial pH and EC. The pH and electrical conductivity (EC) of the mix were at the beginning of the study were 4.55 and 5.0 $dS \bullet m^{-1}$, respectively, as determined by the saturated extraction method. Although this EC level was high, it probably resulted from breaking open fertilizer prills when completing the saturated extraction method. To be sure the medium pH and EC were acceptable after starting the experiment, these chemical characteristics of the media were again measured 1 month after starting the study, but this time they were measured by using the Pour-through method. The pH and EC of the media were 5.91 and 0.5 $dS \bullet m^{-1}$, respectively, one month after planting the seedlings.

The initial aeration, water-holding capacity, and total porosity of the potting mix were also good. The initial air-filled porosity (aeration), water-holding capacity, and total porosity of the potting mix was 25.3%, 42.2%, and 67.5%, respectively. The high percentage aeration of the medium was intentional to be sure that the potting mix drained well to avoid root rot problems for the pinyon pine seedlings, which usually thrive in dry soils.

All plants in the container experiment grew well during the summer. Pinyon pine seedlings survived the transplanting well, most likely because we used plug plants rather than bareroot seedlings. Only two pinyon pine seedlings died, and both were planted in fabric pots. One of these plants was in the shade, whereas the other dead plant received full sun. The rest of the pine seedlings grew a small amount. Only one fir seedling died in this experiment, and this death was due to an error (its spray stake accidentally fell out of the container, and the problem was noticed after the plant was badly wilted).

The shade treatment and type of container used seemed to have minor effects on the overall appearance of the subalpine fir seedlings. All seedlings survived (with the one exception) regardless if the plants were grown in the sun or shade. Fir seedlings grown in typical plastic pots in the shade, however, had darker green needles compared to those grown in plastic pots in full sun. Another interesting observation was that fir seedlings grown in fabric pots in full sun also had darker green needles than those grown in plastic containers in full sun. Perhaps the root temperatures of plants in the fabric pots were cooler due to evaporative cooling of the root system in the fabric, which could have resulted in less root stress and healthier looking shoots.

The shade treatment and type of container used influenced seedling growth of the subalpine fir plants, except for root dry weight, but the effects were somewhat specific. For instance, height increase of fir seedlings during 2006 was affected by light treatment ($P = 0.0041$) and type of container ($P = 0.0379$), but an interaction between these main effects was absent ($P = 0.0505$). Seedlings grown in 55% shade were 1.5 cm (0.6 inch) taller than those in full sun. In addition, seedlings in plastic pots were 0.9 cm (0.4 inch) taller than those in fabric pots. Neither light treatment nor container type affected shoot dry weights of the seedlings (data not shown). An interaction between light treatment and container type significantly affected stem diameters and root dry weights of the seedlings (Table 1). Plants grown in fabric pots in full sun had larger stem diameters than those grown in fabric pots in 55% shade. The stem diameters were only on average 0.48 mm larger for plants grown in fabric pots in full sun compared to plants in any other combination of treatments. In addition, fir seedlings grown in fabric pots in full sun had heavier root dry weights than those of plants grown in plastic containers in full sun. The difference in mean root dry weights between plants grown in these two types of pots was 3.4 g, which was substantial since roughly 10 grams of plant tissue are typically needed to produce 1 gram of dry weight.

Table 1. Effects of light treatment and types of container combinations on mean stem diameters and root dry weights of subalpine fir seedlings.

Treatment combination	Mean stem diameter (mm)	Mean root dry weight (g)
Shade + fabric container	9.2 a[z]	8.8 ab
Shade + plastic container	9.9 ab	9.3 ab
Sun + fabric container	10.2 b	11.2 b
Sun + plastic container	9.3 ab	7.8 a

[z] Means within a column followed by different letters are significantly different as determined by Least Square means at the 5% level (n = 24).

The shade treatment and type of container used had only minor effects on the overall growth of the pinyon pine seedlings, except for root dry weight. The light treatments and container types failed to affect shoot heights ($P = 0.128$) and shoot dry weights ($P = 0.8744$) of the pine seedlings. Seedling stem diameters and root dry weights were affected only by light treatments (Table 2). Plants grown in the sun had the largest mean stem diameters, regardless of the type of pot they were grown in. Plant grown in the sun had - on average - a 1 mm larger diameter than those grown in shade. In addition, plants grown in full sun produced 1 g more root dry weight compared to plants grown in the shade, regardless of the type of container used. One gram of root dry weight indicates a substantial difference in the amounts of roots produced between plants receiving either sun or shade.

Table 2. Effects of 55% shade and full sun on mean stem diameters and root dry weights of pinyon pine seedlings.

Light treatment	Mean stem diameter (mm)	Mean root dry weight (g)
55% Shade	5.7 a[z]	3.1 a
Full sun	6.8 b	4.1 b

[z] Means within a column followed by different letters are significantly different as determined by Least Square means at the 5% level (n = 47).

In general, pine and fir seedlings receiving full sun grew a little better than those grown in 55% shade. Although fir plants grown in shade grew significantly taller, the difference was only 1.5 cm (0.6 inches) between the two treatments. Both fir and pine seedlings grown in full sun had significantly thicker stem diameters, but again the differences is were on average 0.5 mm (0.02 inches) for fir seedlings and 1.08 mm (0.04 inches) for pine seedlings. Although these differences may be statistically significant, their biological significance is probably minimal. Nonetheless, growing conifer seedlings in full sun resulted in the best growth under the experimental conditions in this study.

The type of container used for growing the plants affected only the fir seedlings. Fir plants in plastic containers grew 0.9 cm (0.4 inches) taller than those grown in fabric pots, which may be the result of fabric pots drying out quicker than plastic pots. The faster drying may have stressed the plants slightly causing them to grow less than those in plastic pots. In contrast, the fabric pots in combination with full sun increased stem diameter significantly over those in the other treatments (Table 1). Perhaps the most significant effect of the fabric pots on the fir seedlings was the increased dry weight of roots if plants were grown in full sun (Table 1). The increased root dry weights could be due to air pruning by the fabric bags. In addition, the fabric material could have kept the root systems cooler due to evaporative cooling and provided better aeration of the potting mix, which in turn resulted in more root growth. The fabric bags probably had little effect on the pine seedlings since these plants regenerated fewer roots (compare mean root dry weight of 3.6 g for pine seedlings versus 9.2 g for fir seedlings). Therefore, less root growth would result in less air pruning and fewer roots to form new roots.

Significance to the Nursery Industry

Both subalpine fir and pinyon pine seedlings grew best in full sun, and shading failed to affect their survival rates. The fabric containers appeared to promote growth of the fir seedlings, particularly their root growth. The best combination treatment for the subalpine fir seedlings was to grow the plants in full sun in fabric pots. In addition, needles on fir plants grown in full sun in fabric pots were noticeably darker green than needles on seedlings grown in plastic pots in full sun. The pinyon pine seedlings were unaffected by the fabric containers, perhaps because they regenerated fewer roots than the subalpine fir seedlings. This result was unexpected since we thought that the better-aerated conditions in the fabric pots would promote root growth of the pine seedlings compared to those grown in plastic pots. Apparently slow root regeneration by the pine seedlings limited the fabric pots' effects. Fabric pots should be used when they are shown to promote plant growth since these pots can cost about double the price of an injection-molded or blow-molded pot.

This study demonstrated that <u>plug</u> seedlings of pinyon pine, a difficult-to-transplant species, could be grown in container production since only 2 out of 96 plants (~2%) died. Even with very good transplanting success, more research on improving root regeneration by bareroot pinyon pine seedlings is needed since 2-0 plug plants cost <u>at least four times more</u> than bareroot plants. To make purchasing pinyon pine seedlings more economically viable for specimen nursery growers, root regeneration will have to be improved for bareroot plants, which should also improve transplant survival. I have submitted a new proposal to test the effects of an auxin, naphthaleneacetic acid, on improving root regeneration by bareroot pinyon pine seedlings.